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1. Title of the Invention

Flue gas desulfurization apparatus

2. Scope of the Claims

1. A flue gas desulfurization apparatus comprising:

an absorbing tower in which flue gas containing sulfur dioxide is contacted and reacted with an absorbent for absorbing sulfur dioxide gas,

an oxidizing tower in which calcium sulfite formed in the absorbing tower is oxidized, and

a sulfur dioxide gas feeding means for feeding sulfur dioxide gas to the oxidizing tower.

2. The flue gas desulfurization apparatus of Claim 1, wherein said oxidizing tower comprises:

an flue gas return line for returning part of the gas containing sulfur dioxide which has been discharged from the oxidizing tower to said absorbing tower, and

an flue gas circulating line for feeding back to the

oxidizing tower again most of the gas containing sulfur dioxide which has been discharged from the oxidizing tower.

3. The flue gas desulfurization apparatus of Claim 1, further comprising a line which branches from a flue gas introducing line for introducing flue gas to said absorption tower, so as to feed part of the flue gas to the oxidizing tower.

3. Detailed Description of the Invention

This invention relates to a flue gas desulfurization apparatus, more specifically to a flue gas desulfurization apparatus which is favorable for efficiently recovering gypsum dihydrate or α -gypsum hemihydrate in a short period of time from calcium sulfide obtained by contacting sulfur dioxide gas absorbed from flue gas with an absorbent liquid.

In a conventional flue gas desulfurization apparatus, the sulfur dioxide gas which has been absorbed from flue gas is converted to sulfite ion SO_3^{2-} in an absorption fluid, which will produce calcium sulfite CaSO_3 as the result of reaction with calcium ion Ca^{2+} which is present in the absorption fluid or which is supplied by addition of limestone CaCO_3 or slaked lime $\text{Ca}(\text{OH})_2$. The calcium sulfite is usually fed to the oxidizing tower and oxidized to form gypsum dihydrate $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. It is known that air is used as an

oxidant and an acid such as sulfuric acid is added in order to increase the oxidation rate and to reduce the pH of the calcium sulfite slurry to 6 or less, thereby increasing the contact efficiency between air and liquid.

In addition, in recent years, it has been found that it is advantageous for gypsum recovered from the flue gas desulfurization apparatus to be in the form of α -gypsum hemihydrate in view of processability and strength. The α -gypsum hemihydrate is produced in the oxidizing tower under the reaction condition which allows simultaneous oxidization of the calcium sulfite and conversion to α -gypsum hemihydrate take place. The reaction condition includes pH of the slurry of about 2 to 4 and a temperature of about 120 to 130°C.

That is to say, in order to increase the oxidation rate of calcium sulfite and the conversion rate to α -gypsum hemihydrate, it is required to reduce the pH of the slurry to a prescribed value. However, when gypsum dihydrate and α -gypsum hemihydrate are produced, because the slurry is adjusted so as to have a low pH value and a relatively high temperature, the sulfur dioxide gas which has been absorbed in the absorbing tower of the flue gas desulfurization apparatus is removed from the slurry in the oxidizing tower.

Consequently, the pH of the slurry in the oxidizing tower is increased so that the oxidation rate for calcium sulfite and the conversion rate to α -gypsum hemihydrate are reduced.

The object of this invention is to provide a flue gas desulfurization apparatus which can eliminate the shortcomings of the above-described prior art and in which increase in the pH of the slurry is suppressed during the oxidation of calcium sulfite and the conversion to α -gypsum hemihydrate, so that the gypsum dihydrate or the α -gypsum hemihydrate can be efficiently recovered in a short period of time.

According to the present invention, a flue gas desulfurization apparatus comprises an absorbing tower in which flue gas containing sulfur dioxide is contacted and reacted with an absorbent for absorbing sulfur dioxide gas, and an oxidizing tower in which the calcium sulfite formed in the absorbing tower is oxidized, wherein the oxidizing tower comprises a sulfur dioxide gas feeding means for feeding sulfur dioxide gas.

The following is a detailed description of the invention with reference to a figure.

The figure shows an embodiment in which the present invention is applied to a flue gas desulfurization apparatus for use of a limestone-gypsum method. This

apparatus comprises an absorbing tower 3 in which flue gas containing sulfur dioxide gas is contacted and reacted with an absorbent for absorbing sulfur dioxide gas (absorbent: limestone slurry in this example) and an oxidizing tower 9 in which the calcium sulfite formed in the absorbing tower 3 is oxidized. The oxidizing tower 9 functions as a tower for oxidizing calcium sulfite and forming gypsum dihydrate when the end substance recovered is gypsum dihydrate, while it functions as a tower for oxidizing calcium sulfite and also for converting it to α -gypsum hemihydrate when the end substance to be recovered is α -gypsum hemihydrate.

The number 12 represents an air feed line in the figure, and a sulfuric acid gas cylinder 11 is connected to the air feed line 12 as a sulfur dioxide gas feeding means. The air feed line 12 connects with a line 16 which branches from the flue gas introducing line 14, and in the case where the flue gas contains a high concentration of sulfur dioxide gas, part of the flue gas is introduced into the air feed line 12. The oxidizing tower 9 and the flue gas introducing line 14 are connected through the flue gas return line 13. The flue gas circulating line 15 which branches from the flue gas return line of the oxidizing tower connects to the air feeding line 12.

In the flue gas desulfurization apparatus for use of

the limestone-gypsum method, the limestone slurry is fed to the absorption liquid slurry circulating tank 2 through the limestone feeding line 1 and then sent to the absorbing tower 3. In the absorbing tower 3, the slurry comes in contact with the gas containing sulfur dioxide gas SO₂ so as to absorb the SO₂. The absorbed SO₂ is converted to sulfite ion, and reacted with calcium ion formed by dissolution of the limestone to produce calcium sulfite. The absorbing tower 3 is operated such that the pH of the slurry is kept at about 6.0, so as to increase the efficiency of SO₂ absorption.

A portion of the slurry being circulated in the absorbing tower 3 and the circulation tank 2 is led to the cooling tower circulation tank 5 through the cooling tower circulation tank feeding line 4. The slurry which has been stored in the cooling tower circulation tank 5 is fed to the cooling tower 7 through the cooling tower circulation line 6, where the slurry comes in contact with gas containing SO₂ to absorb SO₂ further, while evaporating the water. Thus, the sulfite ion concentration in the slurry increases so that the pH decreases.

The slurry is prepared such that the pH is 5 or less, more preferably 2 to 4 and a portion of the slurry is sent to the oxidizing tower 9 through the oxidizing tower

feeding line 8. At this stage, in the case where the pH of the slurry is not reduced to a prescribed value, there may be a residue of the unreacted limestone in the slurry. Then, sulfuric acid is added to the oxidizing tower 9 so that the pH of the slurry is reduced to the abovementioned value.

In this example, because oxidization of calcium sulfite and conversion to α -gypsum hemihydrate take place in the oxidizing tower 9, the temperature of the slurry can be maintained between 120 and 130°C with simultaneous adjustment of pH of the slurry. The temperature of the slurry can be adjusted by feeding steam to the oxidizing tower 9 through the steam feeding line 10, and at the same time, by feeding the make-up water for evaporated water to the oxidizing tower 9, so that the slurry concentration is kept constant.

In the oxidizing tower 9, because the SO₂ in the slurry is removed and the pH of the slurry is increased accordingly, SO₂ corresponding to the amount of SO₂ that has been removed is fed from the sulfur dioxide gas cylinder 11 along with the oxidation air through the air feed line 12 to the oxidizing tower 9.

Because the gas discharged from the oxidizing tower 9 has a high concentration of SO₂ and steam, part of the gas

is returned to the absorbing tower 3 through the flue gas returning line 13 and the flue gas introducing line 14, while most of the gas is returned to the air feed line 12 through the flue gas circulating line 15. In this manner, the SO₂ in the gas discharged from the oxidizing tower 9 is used again for formation of calcium sulfite, oxidation of calcium sulfite and conversion to α -gypsum hemihydrate. Thus, the overall desulfurization efficiency of the plant can be increased.

In addition, in the case where the gas treated in the flue gas desulfurization apparatus contains high concentration of SO₂, a portion of the gas may be added through the line 16 to the oxidation air fed through the line 12. The amount of SO₂ fed from the sulfur dioxide gas cylinder 11 is controlled by the amount of SO₂ fed from the line 16 so that the overall SO₂ amount corresponds to the amount of SO₂ removed from the oxidizing tower 9. The pH of the slurry in the tower is kept constant by replenishing the SO₂ in the oxidizing tower 9.

The slurry that has reacted sufficiently in the oxidizing tower 9 is sent to the filter 16 for solid-liquid separation. When α -gypsum hemihydrate 17 is left at 90°C for a long period of time during the solid-liquid separation, it is converted to gypsum dihydrate. Thus, it

is desirable to filter it quickly. The preferable solid-liquid separation condition includes the temperature of 90°C or less within 5 minutes.

When the capacity of the apparatus is selected such that liquid feeding can be done continuously, a process control becomes simple. Of course, the oxidation of the calcium sulfite slurry can be done in batches.

The above-described process operations are for producing α -gypsum hemihydrate. When gypsum dihydrate is produced, a condition suitable for production of gypsum dihydrate should be set in the oxidizing tower 9. Because the amount of SO₂ removed from the slurry in the oxidizing tower 9 is also different in the case where gypsum dihydrate is produced, the amount of SO₂ which is fed from the sulfur dioxide gas cylinder 11 can be suitably controlled.

According to this invention, because increase in the pH of the slurry in the oxidizing tower can be suppressed, decrease in oxidation rate of calcium sulfite and conversion rate to α -gypsum hemihydrate is prevented so that gypsum dihydrate or α -gypsum hemihydrate can be produced efficiently in a short period of time.

4. Brief Description of the Drawing

The figure shows the schematic structure of an embodiment of this invention.

- 3: absorbing tower,
- 9: oxidizing tower,
- 11: sulfur dioxide gas cylinder,
- 13: flue gas return line, and
- 15: flue gas circulation line.

